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Bryan Parker
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Dear Mr. Parker,

Please see enclosed documents regarding a test plan for emissions permitting data for Volunteer Environmental Services (VES) in Covington, TN. As a preliminary matter, I am not engaging this effort as an Alabama Bar Member, but more limited as a technical consultant for the matter at hand. I have special knowledge about this Covington facility as I am one of the named inventors of this technology, was the Lead Process Engineer in the facility's construction, and have conducted 3 prior emissions test plans at this facility while I was employed by the previous owner. My Law Office is simply a business-in-good-standing that I can contract with VES to oversee this test plan until such time as I can engage in an Engineering Services Agreement with VES under my current employer Process Engineering Associates, LLC (Oak Ridge, TN).

As a basic principal, solid organic materials do not combust in their physical state as a solid. Rather, solid incinerators burn a film of gas that emanates from the solid surface once the solid has been heated to a state of molecular instability. The process is perpetuated as the heat from the burning film of gas sustains the molecular instability of the solid until it is nearly completely evaporated. The second requirement of solid fuel incineration is supplying sufficient supplemental oxygen to sustain the combustion of the gas film around the solid. This is where direct incineration becomes problematic. To ensure oxygen flow from the surrounding hot environment into the combusting film, a significant amount of turbulence is needed, which has the unwanted side-effect of fluidizing residues and non-combustible constituents of the solid fuel. This most always translates into carryover of ash and soot into downstream equipment, into the flue stack gases, and out into the environment. Consequently, costly equipment must be installed to capture these particulates and mitigate there release to the best extent achievable.

An alternate approach to direct incineration involves a concept that easily dates back to the early 1900's and has even been highly-promoted by the USEPA as a preferred technology for combustion of solid phase fuels. This process first brings the solid to thermal instability under a controlled, near laminar-flow gas phase passing through the solid. This approach to combustion fundamentally reduces or nearly eliminates the turbulent forces that would otherwise fluidize and transports these residues and non-combustible solids into the flame environment. In essence, gasification as a pre-step separates the "gas film" from the solid fuel and subjects only these gases to the turbulent air regime required to completely combust the fuel. This approach has been widely used in recent decades as a much better means for using solid fuels for energy release. The primary impediment to wide-scale adoption of this approach to combustion has been that industrial-grade equipment that can withstand the thermal rigors of the gasification pre-step have been difficult to attract capital investment. Many projects in the past have failed because the gasification equipment can only run stably under tightly-controlled conditions, and even then, some have required frequent and costly maintenance cycles to sustain their operation.

Around 2010, our investors and research engineering team decided to develop industrial-grade gasification equipment that was not plagued by the maintenance and control issues of the past and that used a new generation of materials that could withstand long-term the thermal rigors of the gasification pre-step. As additional design features, we decided to make as wide a range of solid organic materials as suitable feedstock and to make it scalable so as to ensure that its usefulness would be attractive to largest possible marketplace. The platform we chose was the Downdraft Gasifier concept, which was extensively studied by the EPA in the 1970's. After 6 or so years of concept-to-commercialization effort, our team placed the first industrial, high-performance downdraft gasifiers in Gleason, TN at the Boral Brick facility. Six of these gasification reactors were installed in parallel to produce a combustible fuel gas from woodchip to offset natural gas usage in the brick kiln. Subsequent to that project, the 7th reactor was built in Covington, TN and the 8th unit, the largest downdraft gasifier in the World, is currently operating outside of Nashville.

Over the years of this commercialization effort, we have tested a wide range of solid and liquid fuel types ranging from oil-field waste liquids, agricultural crop residues, spent rubber tires, and construction debris. As scientists, what we learned is that most any material that is comprised of C-H or C-H-O (i.e., hydrocarbon or organic) become thermally unstable at a certain point. Therefore, with a baseline of chipped wood waste as the substrate, many other types of problematic wastes could enter the reactor and be molecularly decomposed along with the woodchip. As you know, this concept was successfully demonstrated in the Covington facility as we injected a controlled-rate of dewatered sewage sludge into the unit along with the woodchip baseline. And, we successfully conducted at least 2 different emissions studies on this blend of solid materials. The concept of a woodchip baseline plus a second solid that is very difficult to combust was also proven successful and permittable for blends of chip and chunk rubber tire in AL.

The concept that VES noticed very early on was that, like sewage sludge, some materials are more problematic to dispose by landfill. As you probably know, landfilling is a version of biological gasification that is spread-out over many years and leaves a concentrated residue that can be environmentally toxic for many centuries after the organics have evaporated away. Moreover, the emanating biogases simply enter the surrounding air and potentially pose an even greater environmental risk.

Medical wastes clearly present their own host of problems with landfilling. However, by first establishing stable gasifier operation on woodchip and then introducing a controlled-rate of medical waste into the unit, the organic content therein can be safely decomposed into combustible elemental gases, whose residual energy content can further be used to generate electricity. In my opinion, this approach is by far a better solution than landfilling these types of wastes. We have already conducted short-run tests of the type of medical wastes VES sources and have seen no adverse reactions to the gasifier stability when operating on a blend with chipped wood waste.

A study published by the Cambridge University press in 2016 determined that hospital waste is consisted of:

- 99.02% combustible wastes and 0.97% noncombustible wastes by mass.
- Waste constituents:

- Paper (16.17%),
- Textiles (9.77%),
- Cardboard, wood, and leaves (1.12%),
- Food waste (21.5 1%),
- Plastics (50.45%).
- Metal and Noncombustible waste (0.40%), and
- Glass (0.57%)

- Proximate Analysis (wt. %)
  - Moisture (38%),
  - Ash (4% )
  - C-H-O (58%)
    - C-H (38%)
    - O (15%)
  - HHV 6,115 Btu/lb

Chipped wood waste from the Covington area during the last Emissions Test plan conducted at the site showed:

- Proximate Analysis (wt.%)
  - Moisture (46.3%)
  - Ash (2.2%)
  - C-H-O (51.5%)
  - Sulfur (0.04%)
  - HHV 5,368 btu/lb
- Ultimate Analysis (wt.% dry)
  - C-H-O (95.5%)
  - Ash (3.8%)
  - Nitrogen (0.6)
  - Sulfur (0.07%)

As you can see, chemically speaking, the medical waste is not all that different than the wood waste. Medical waste has a slightly higher HHV due to its higher ratio of Carbon to Oxygen, resulting from the presence of plastics (hydrocarbon). Our experience has shown this level of difference is relatively minor to how they decompose inside the gasifier. The largest dictator to stability of gasifier operation is by far the total moisture content. This is why we designed the Covington facility with a woodchip dryer to reduce the natural moisture content of green wood waste prior to entering the gasifier.

Our proposed test plan will be as follows:

1. Mobilize Test Team to site and function test each piece of unit equipment and instrumentation and make any necessary repairs to ensure reliable operation of all critical parts and communication with the SCADA control system (Step time: 1-2 days depending on current conditions of the system).
2. Clean and inspect the gasifier unit and ceramics to confirm suitability for operation (Step time: 1 day).
3. Determine the wood weight rate on each feed cycle by collecting, weighing and averaging at least 3 fill dumps using a catch bucket. Adjust conveyor run-time to charge around 40-50 lbs of chip per fill cycle.
4. Establish stable gasifier operation on woodchip at a rate of around 8 tons per day. Allow producer gas temperature exiting the gasifier to reach steady-state for at least 6-8 hours (Step time ~10-12 hours). Maintain oxidizer temperature above 1,800°F and a minimum of 5% excess O2.

5. Begin adding one individually sealed Medical Waste bag by hand into every other woodchip feed tube during each batch feed cycle, record the weight of each bag added by placing a scale up on the feed deck (Step time: 4-6 hours). Confirm that the feed auger is not jamming by the whole bags being placed in with the chip charges. Medical waste rate should be around 6.5% of total feed weight rate. (auger should have enough torque to shred the bags and blend with the incoming chip).
6. Confirm reactor stability, then increase Medical Waste bag addition rate to one bag each feed cycle for approximately 12-13% Medical Waste feed rate by weight (Step time: 2-4 hrs.).
7. Confirm reactor stability, then increase Medical Waste bag addition to rate to one bag every other fill cycle and two bags for alternate feed cycle to bring the Medical Waste rate to around 18-20% of total feed rate. (Step time: 2-4 hrs.).
8. With emissions monitoring equipment in-place and ready, start first 1-hour run of the stack gases while maintaining Medical Waste feed rate at 18-20% of the total feed rate (Step time: 2-3 hours, depending on any calibrations or issues with the test contractor)
9. Conduct a second 1-hour emissions test while maintaining 18-20% Medical Waste feed rate at around 18-20% of the total feed rate. (Step time: 1-2 hrs.).
10. When emission contractor confirms completion of the 2nd monitoring run and data set is good, cease adding Medical Waste bags to the feed tube and run the gasifier just on woodchip for at least 60 feed cycles to ensure all of the medical waste has been consumed in the system (Step time: 2-3 hours).
11. Disable the gasifier feed system and allow internal chip inventory to draw down to Low-Low level alarm. Then, shut the unit down (Step time: 1-2 hours).

Other Test Notes:

- Grab at least two biochar samples from the residue bin during each of the two stack test runs.
- Grab at least two woodchip samples both before and after the dryer during each of the two stack test runs.
- Set aside one medical waste bag from each stack test run.
- Send all samples to a lab for ultimate and proximate analyses and forward results to emissions test contractor.
- Record all unit operating conditions (Temps, Pressures, Feed Cycles, biochar rates, etc.) during the operational test time (the SCADA is already set-up to do this and will download a datafile on the local hard-drive).

Estimated Total Woodchip consumption: ~12 tons
Estimated Total Medical Waste consumption: ~1 ton
Total Estimated Unit Run Time to Completion: 30-36 hours

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Please feel free to contact me if you any other questions or concerns about this Test Plan.

Kindest Regards,

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Mark O. Loftin, J.D., B.S.Ch.E.